PERIODICAL ASSESSMENT OF PATIENT RELATED FACTORS AND SETUP ERRORS THAT AID IN REPLANNING IN HEAD AND NECK CANCERS

A PROSPECTIVE STUDY

A dissertation submitted to The Tamilnadu Dr. M.G.R. Medical University, Chennai In partial fulfillment of the requirements for the award .The degree of **DOCTOR OF MEDICINE (M.D.) IN RADIOTHERAPY** April 2016

CERTIFICATE

This is to certify that this dissertation titled, **"PERIODICAL ASSESSMENT OF PATIENT RELATED FACTORS AND SETUP ERRORS THAT AID IN REPLANNING IN HEAD AND NECK CANCERS: A PROSPECTIVE STUDY."** is a bonafide record of the work done by Dr.Priyadharsini.D.K, in the Division of Radiation Oncology, Cancer Institute (W. I. A.), Chennai, during the period of his postgraduate study for the degree of M.D. (Branch IX – Radiotherapy) from 2014-2015 under my direct guidance and supervision.

Date:

Place: Chennai

Dr.G.Selvaluxmy,
Professor and Head of Department,
Division of radiation oncology,
Cancer institute, (WIA), Chennai

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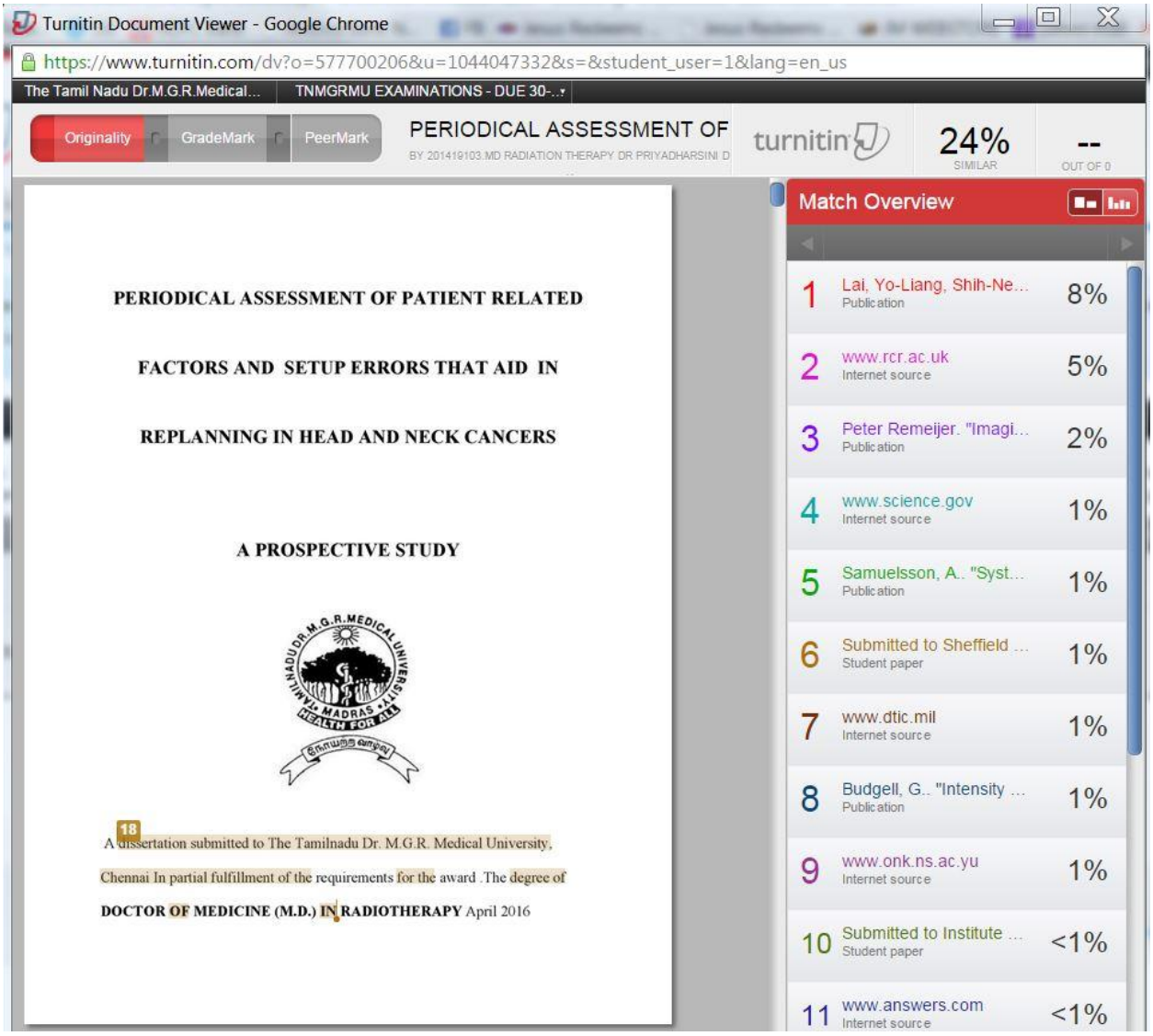
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ABSTRACT

PERIODICAL ASSESSMENT OF PATIENT RELATED FACTORS AND SETUP ERRORS THAT AID IN REPLANNING IN HEAD AND NECK CANCERS A PROSPECTIVE STUDY

Dr.Priyadharsini.D.K, Cancer Institute (WIA)

Aim:To analyse the effect of body mass factors before radiotherapy and changes occurring on course of radiation leading to setup error in patient with head and neck cancers and need of replanning.

Materials and methods: This is the prospective study and clinical data of 50 patients with oropharynx, hypopharynx, nasopharynx cancer was analyzed using daily on-line 2D KV image. BMFs included weight, height, circumference and thickness of neck. Alterations in the Body mass factors during treatment were

recollected from CBCT at 10th and 20th fractions. Repeat CT for RT planning done at 40 Gy for all patients.The initial CT and replan CT were registered and the structures contoured in initial CT were copied to replan CT to analyze the dose volume effect and NTCP if no Re CT and replan was done. Using BMFs the effect of the factors on magnitude of displacement was statistically analyzed.

Results: Higher body weight before radiotherapy was asscociated with greater setup errors. Among the ratios of the body mass factors during radiotherapy, the measures at the level of mastoid tip at 20th fraction were associated with more setup error. TCP was significantly better and NTCP was significantly reduced.

Conclusion: For the patients who have large reduction ratio in circumference (<1) and thickness (<0.94) at the level of mastoid tip at 20 th fraction we should consider adaptive radiotherapy which improves TCP and decreases NTCP.

Key words:Body mass factors, setup errors, adaptive radiotherapy.

I.INTRODUCTION

Radiation therapy concomitantly with chemotherapy is a choice of multi-modality treatment for head and neck cancer. Intensity modulated radiation therapy (IMRT) has become common now a days because we can achieve target dose with sparing of normal tissues. But we should be careful in patients' setup accuracy as IMRT causes steep dose gradients. In head and neck cancers correct fitting of the immobilization device, change in body contours, and treatment-induced changes such as tumor regression and cell death, tumor growth resulting from accelerated repopulation, weight loss due to emaciation or weight gain because of changes in appetite caused by radiation, concomitant chemotherapy, normal tissue fibrosis, all lead to setup abnormalities during course of radiation. Causes might be independent or related to the others. Insufficient compensation for these uncertainties leads to target under dosing and overdosing of nearby OARs, whereas overcompensation for uncertainties leads to unnecessary irradiation of normal tissue and constraints in treatment planning. This creates a tradeoff between tumor control probability (TCP) and normal tissue complication probability (NTCP) and emphasizes the role of minimizing uncertainties to enhance the therapeutic ratio of radiation.Daily Online image guidance helps in correcting these setup uncertainitiesBut IGRT is not always feasible .For patients with anatomic changes

due to tumor shrinkage or weight loss adaptive radiotherapy is considered. But increased costs, higher staff workload, and higher radiation doses to the patients should also be considered. So still we have to evaluate the need of suitable indications for adaptive radiotherapy in head and neck cancers.

Radiation therapy (RT) is thel use of ionizing radiation as a part of cancer treatment to control tumor cells. Etymology: In Latin radiare means to emit rays; and in Greek therapeia means treatment. Thus Radiation is the treatment of malignancy by using ionizing radiation to deter the proliferation of malignant cells. The origin of radiotherapy followed on from three major scientific discoveries late in the 19^{th} century: the discovery first of x-ray by the famous German physicist, Wilhelm Conrad Roentgen in 1895, then radioactivity by Henry Becquerel in 1896 and Radium by Madame Curie in 1898.

Radiation varies in types and mode of delivery also differs.. The various types of ionizing radiation used in radiotherapy are X-radiation, gamma radiation, electrons, protons and neutrons, of which gamma rays and high energy X-rays are in common practice. Iomisation is the process by which cancer cells are killed.. Direct action of radiation kills cancer cells immediately but indirect action is the

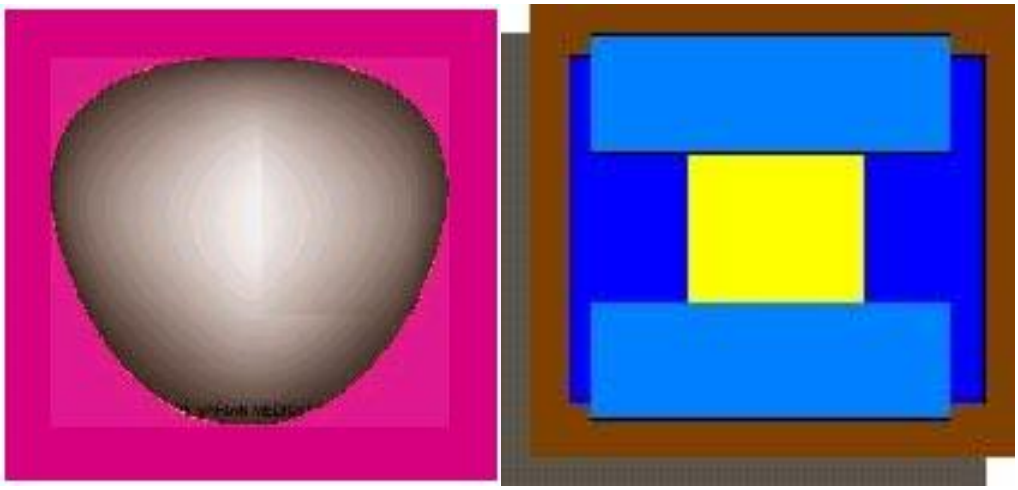
predominant one. Eventhough radiation kills both cancer cells and normal tissues most of the normal tissues will recover from effect of radiation.

BASIC PRINCIPLE OF RADIOTHERAPY

Radiotherapy aims to deliver uniform dose distribution to the target volume which includes the tumor (GTV), sub-clinical spread of tumor cells (CTV) and margin to account for patient movement (PTV), organ movement and day-to-day variations in patient set-up. Hence we should keep radiation dose to normal tissues to low as possible. Hence more efforts should be done to deliver more accurate dose to target volume.

Conventional External Beam Radiotherapy:

Conventional EBRT is delivered by beams of square or rectangular shape. This technique is well established and is generally quick and reliable. The limitation is the escalation of dose to tumor is limited due to the tolerance limit of the nearby critical organs.



conventional RT showing rectangular beam shaping

Three Dimensional Conformal Radiation Therapy:

Three dimensional conformal therapy (3D CRT), is based on 3D anatomic information and use dose distribution that conforms dose to the target volume to t and to keep minimum possible dose to normal tissue. The beams are shaped with Multi Leaf Collimator controlled by computer system. The irregular shaped fields provide better avoidance of normal tissue.

MLC

The main distinction between treatment planning of 3D CRT and that of conventional radiation therapy is that the former requires the availability of 3D anatomic information and a treatment planning system. The important milestone which sparked in a revolution in not only radiological diagnosis but also in radiotherapy was the invention of x-ray CT. CT was introduced to the radiptherapy process at the end of 1970's and this resulted in 3D treatment planning, now a standard tool in radiotherapy. The anatomic information is obtained in the form of closely spaced transverse images, which is processed to reconstruct anatomy in any plane,and in three dimensions. Depending on the modality which we image critical structures and visible tumors are outlined slice by slice using planner.

Limitations of 3D CRT:

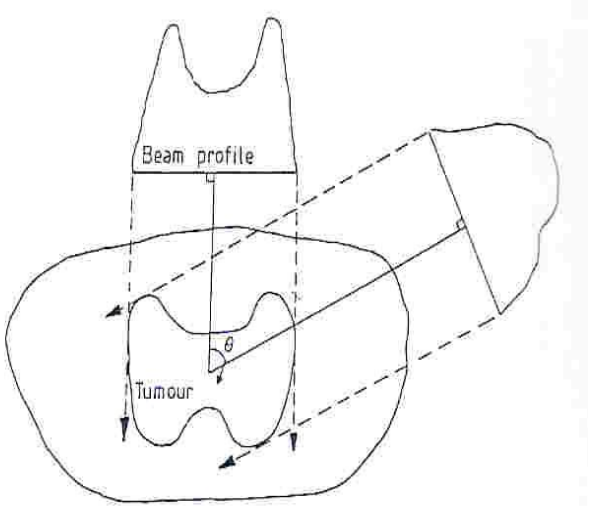
Traditional radiation t techniques, including 3D CRT, not provides a method for sparing critical structures that push into and are partially or fully surrounded by a target. To overcome this problem new treatment methods are introduced in external radiotherapy. The intensity modulated radiotherapy provided more conformality than any other technique.

1) INTENSITY MODULATED RADIATION THERAPY (IMRT):

The first clinical IMRT treatment delivery was in 1994 with serial tomotherapy device and then MLC-based IMRT, which was first implemented into clinical use at Memorial Sloan-Kettering Cancer Center in 1995.

The IMRT technique is most advanced forms of conformal treatment which improves Tumor control probability and decreases normal tissue complication probability. It is based on inverse treatment planning for determination of the required intensity modulated beams and on 3-D multi-modality imaging to define the target volumes. Focusing a higher radiation dose to tumor while minimizing radiation exposure to surrounding normal tissues is possible using IMRT. IMRT also has the potential to reduce treatment toxicity, though doses are not escalated.

Manipulation of intensities of individual beamlets within each beam is the most important advantage of IMRT thereby enabling customized dose distributions. In particular, IMRT provides better normal tissue sparing by its ability to produce non uniform fluence and hence can generate concave shaped dose distributions. Beam comprising a combination of deliberately modified intensities form an intensity modulated beam (IMB) and treatment delivered by such a beam is called intensity modulated radiotherapy (IMRT).



CONCEPT OF INTENSITY MODULATION

Basic Modes:

IMRT treatments is delivered with the MLC operating in one of two s modes:

1. The segmented MLC –Step and shoot method.
2. The dynamic MLC (DMLC) mode,-Sliding window technique

In step and shoot method the intensity modulated fields are delivered with a sequence of small segments or subfields, each subfield with a uniform intensity. The beam is turned on only when leaves are stationary in each given subfield position.

In the dynamic MLC mode -Sliding window technique the intensity modulated fields are delivered in a dynamic fashion with the leaves of the MLC moving during the irradiation of the patient.

1. First we have to do treatment planning and delineate target and normal structures.
2. Then we have to do Image guidance and treatment verification using electronic portal imaging device which corrects using matching of bony anatomy and reference markers.

3. PET Scan and CT scan are used during follow up for assessment of tumor response using geometric calculation.

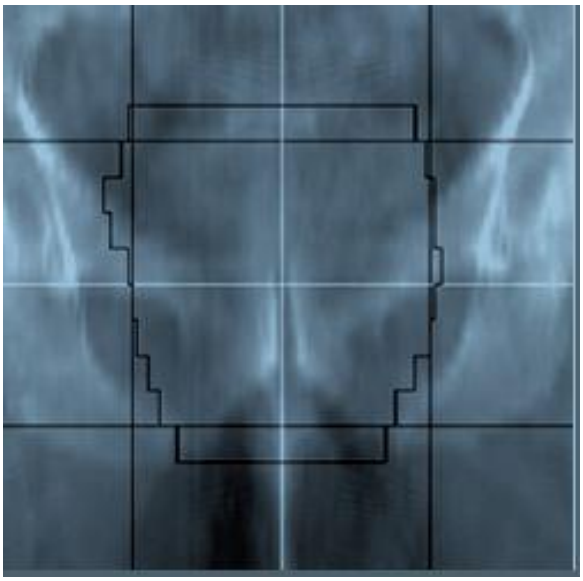
IMAGE MODALITIES AVAILABLE:

1. KV X-Ray imaging using OBI
2. MV imaging using EPID.
3. Fan beam CT
4. MV CBCT-Used for image guided application on conventional accelerators.
5. KV CBCT-It is used for bony anatomy.
6. MRI-Fused with CT.
7. PET-Mainly used for lung cancers, also used in nasopharyngeal cancers.

8. US-has only limited accuracy.

9. SPECT.

DIGITALLY RECONSTRUCTED IMAGE



SIMULATOR:

1. Reference KV image in planned treatment position.
2. For comparing pretreatment verification the reference image should be compared with planned image.

CT SIMULATOR AND VIRTUAL SIMULATION SOFTWARE:

1. It is used for virtual simulation procedure.
2. For geometric verification digitally reconstructed images are used.

TPS:

1. For Importing CT/MRI/PET CT data for planning treatment.

2. Image for geometric verification is image of CT simulator.

ELECTRONIC PORTAL IMAGING DEVICE:

1. They are taken during treatment delivery using MV treatment beam.

FILM:

1. They are traditional radiographic medium taken during treatment delivery using MV beam used for treatment.

2. Similar to diagnostic radiology a fiml cassetee loaded with radiochromic film is placed in the beam exit of the patient.

COMPUTED RADIOGRAPHY:

1. The plate which is insensitive to ambient light and reusable is place inside a traditional cassette.

2. Digital radiographs are made by reading the photographic plates in a special reader.

IMPLANTED MARKERS:

1. Fiducial markers of bio-compatible elements like gold seeds or gold wire coils are placed inside the target volume, preferably in soft tissues
2. They are seen in portal images taken with film and EPIDs.

IN ROOM ULTRASOUND:

1. Used for visualizing soft tissue

2. Real time positioning of the target volume can be carried out using ultrasound imaging on the treatment couch prior to treatment.

IN ROOM KV IMAGING:

1. Floor and ceiling mounted diagnostic X ray tubes and image intensifiers to give orthogonal images.
2. Both static and dynamic images are taken to verify patient setup before and after treatment delivery and necessary adaptations can be done in the treatment plans on an on-line basis.

INROOM CT IMAGING:

1. The CT-On rails is advanced technique where a common couch is shared between the treating LINAC and the CT machine and the CT machine moves through the couch to acquire CT images just prior to treatment execution.

KV CBCT:

1. An advanced amorphous silicon detector and a KV X-source are attached to the gantry of the treatment machine such that the KV and MV beams are orthogonal to each other.

2. CBCT of the entire volume of the region of interest of treatment shall be scanned and a half-beam scan or a full beam scan can be used depending on the diameter of the volume to be imaged.

MV CBCT:

1. Megavoltage therapy X beam itself or a dedicated 1MV X beam can be used to take CBCT images using the EPID attached to the treatment gantry.
3. Since the isocenter is same for both imaging and treatment, an entire volume of interest shall be imaged with single setup with much ease.

CONE BEAM SIMULATOR:

1. This is identical to the treatment machine.
2. Cheaper solution and a substitute for relatively costlier KV fan beam CT simulation where the image resolution is inferior to fan beam CT as the slices are reconstructed from the volume image information obtained.

TOMOTHERAPY:

1. Tomotherapy incorporates the technology used in fan beam CT machines and hence getting the advantage of n number of rotations without the limitations as we have in other modern LINACS.
2. This is achieved by replacing a KV source with a MV source to rotate around the couch which moves in during beam ON to provide speedy delivery of

treatment and the binary MLCs takes care of the modulation required to provide the intensity modulation.

SURFACE AND MARKER TRACING:

1. It measures optically the position of markers placed superficially on the patients' skin relative to reference a point.
2. Light of optical or infrared wavelength used.
3. This is performed continuously throughout the treatment delivery and setup and no radiation exposure associated with this.

MR LINAC/MR COBALT SOURCE:

1. Uses very high quality soft tissue imaging principle of magnetic resonance and used for image guidance during delivery of treatment.

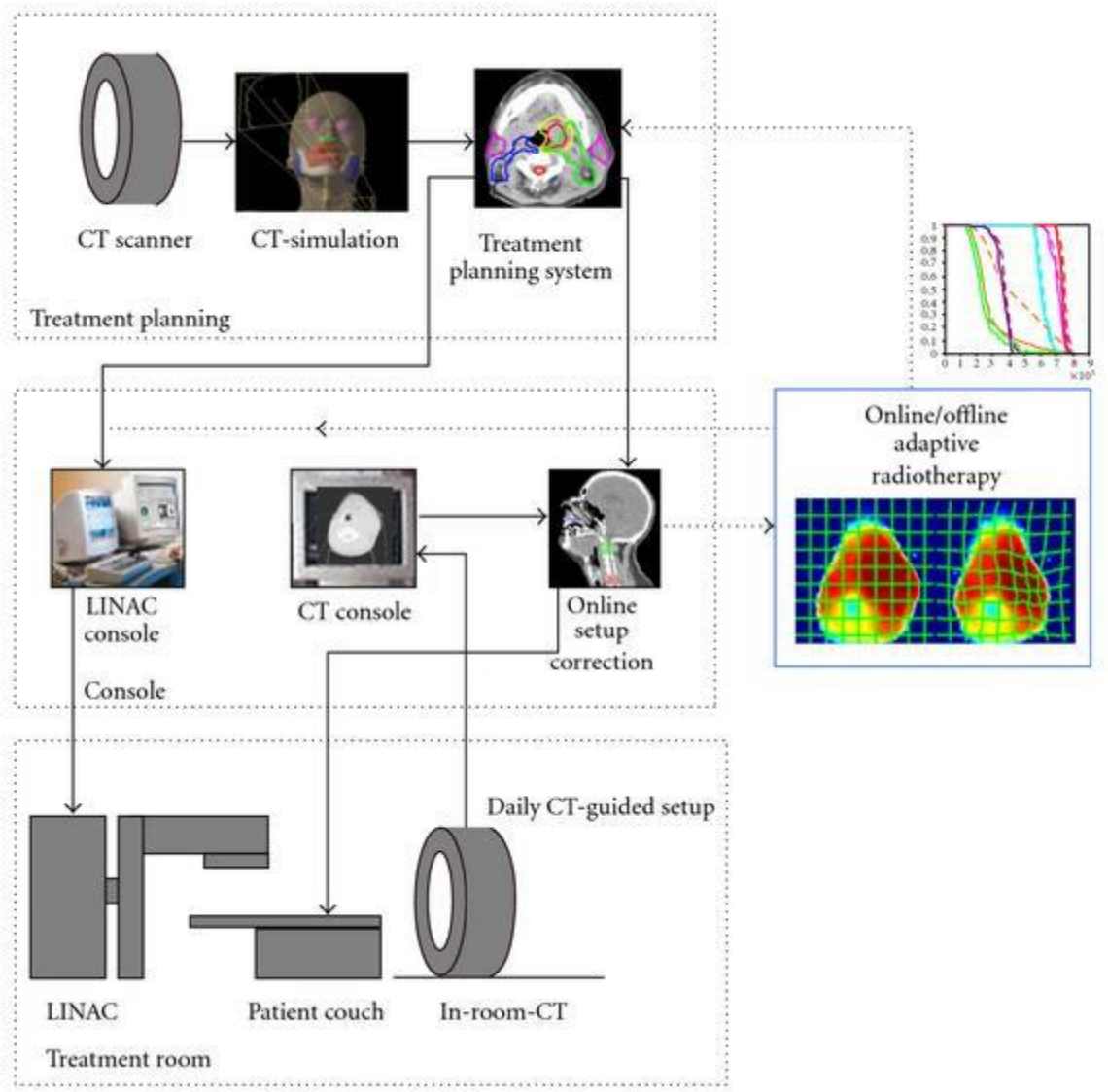
GATING:

1. It is a method of assessing respiration during treatment delivery.
2. By Tracking the movement of external surrogates during course of treatment which indicates when target volume is centered on treatment isocentre.
3. A relation between external surrogate marker (usually a six dot IR reflector) and the movement of internal organs were established.

2) ADAPTIVE RADIOTHERAPY:

For a range of clinical radiotherapy cases, the treatment plans optimized based on the initial set of computed tomography (CT) images become suboptimal for subsequent irradiations due to deformations of the relevant structures. The central idea behind Adaptive Radiotherapy (ART) is that adaptation of a treatment plan over the entire course of radiation treatment can, result in better therapeutic ratios than those that would have resulted from delivery of the initial single treatment plan. In routine practice, treatment plans are done with single CT image set acquired prior to the treatment course and that plan is usually evaluated using DVHs. DVHs based on a single scan may incorrectly estimate the delivered dose. Typically in response to weight loss or other "significant" morphological changes, plans are adapted for patients.

Adaptive radiotherapy is being practiced around the world in various forms. Re-Plan based on Re-CT after therapeutic dose of at least 40Gy is one of the most common techniques of ART being practiced.

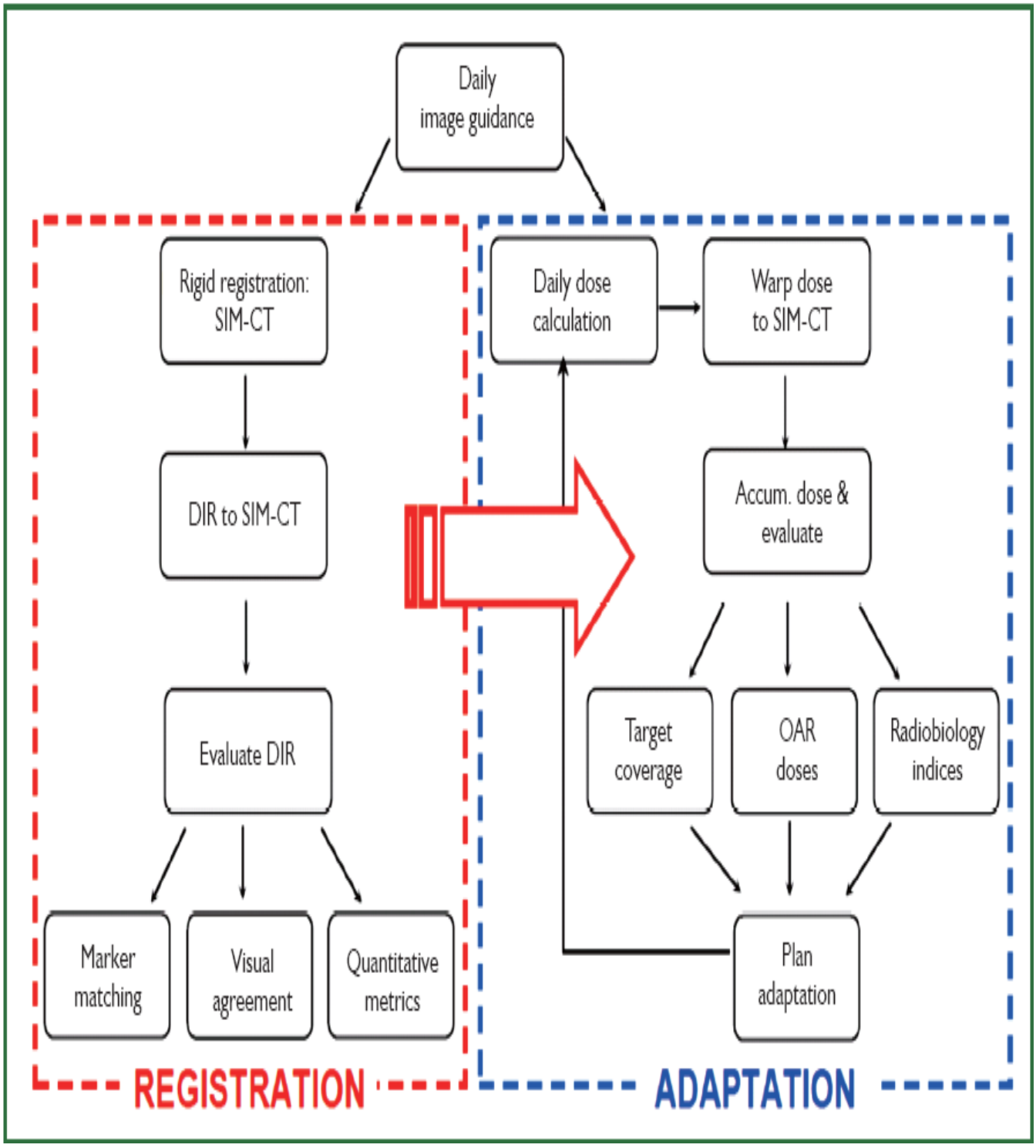


For sites involving intra-fractional movements of the organs at risk and the target itself, such as esophagus, a four-dimensional CT is acquired and it is binned into a nominal 10 phase CT series. Plans for each phase are generated in the treatment planning systems and based on the CTV position on a particular day of treatment

which is obtained from CBCT acquired prior to the treatment delivery the corresponding best suited phase treatment plan is treated.

In pelvic site tumors such as cervix and prostate, the rectal and bladder fillings make a significant change in the target positions and this can be assessed based on the daily CBCT acquired prior to the treatment and necessary changes in plan chosen for delivery or repositioning the patient.

ART and image guided radiotherapy has become interlinked and hence modern radiotherapy delivery machines with advanced imaging technologies are widely preferred to deliver a better clinical results in patients.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Rigid registration:
SIM-CT
DIR to SIM-CT
Evaluate DIR
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Visual
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REGISTRATION
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calculation
Warp dose
to SIM-CT
Accum. dose &
evaluate
Target
coverage
OAR
doses
Radiobiology
indices
Plan
adaptation
ADAPTATION

3) AN OVERVIEW OF SETUP ERRORS:

GEOMETRIC UNCERTAINITIES IN RADIOTHERAPY:

DELINEATION ERRORS

Misplacement in delineated contour with respect to tumor. Error in target volume delineation may be the single largest error in the whole radiotherapy chain in modern radiotherapy protocols.

PLANNING ERRORS

These errors are caused by wrong beam set up and wrong margins to the CTVs and GTVs due to uncertainties in the contouring process using single modality images. By proper quality assurance and regular verification of plans by physicists may help in eliminating these such errors.

ORGAN MOTION:

This error is mainly due to the movement of tumor with respect to bony landmarks. It occurs either during treatment planning or treatment execution.

SETUP ERRORS:

A shift in the isocentric position when an image is compared against its corresponding reference i.e., the calculated deviation between actual and expected

position is known as set-up error. To maintain correct direction information on shifts, vector calculations are done and shifts in anterior directions are given positive sign whereas shifts in posterior directions are negative sign. Types of setup errors 1.Gross error 2.Systematic error 3.Random error

Gross error is defined as an unacceptably large set-up error that could underdose part of the clinical target volume (CTV) or overdose an organ at risk. As the CTV to PTV treatment margins do not account for errors of such magnitude, gross errors need to be corrected earlier to the commencement of treatment.

Systematic error is defined as the error which occurs for each fraction throughout the treatment in same direction and similar magnitude.

Possible cases of gross errors are

1.Incorrect patient.

2,Incorrect patient orientation.

3.Incorrect anatomical site.

4.Incorrect field size.

5.Incorect field shape.

6.Incorrect isocenter position of unacceptable magnitude.

The preferred method to correct gross error is to image on the first treatment fraction immediate to treatment delivery.

In general, a 10mm error is taken as the level for action in a wide range of sites.

SYSTEMATIC ERROR:

It is the deviation that occurs in same direction and is of similar magnitude for each fraction throughout the treatment course.

It is classified into individual and population systematic error.

INDIVIDUAL SYSTEMATIC ERROR:

The systematic error of the individual Patient is the mean error over the course of treatment.

POPULATION SYSTEMATIC ERROR:

It is the systematic error for the group of patients.

It is calculated as the standard deviation of mean errors for each patient.

Causes of systematic error may be:

1. Target delineation error: the difference between ideal CTV and the delineated CTV is considered as target delineation error

2. Target position and shape: when the position of target contoured and planned differs from that of the shape and position during treatment.

3. Phantom transfer error:

It is accumulated when transferring image data from initial localization through TPS to the linear accelerator.

They are classified as systematic because causes of phantom transfer do not change and it varies slowly (isocentre position and leaf accuracy positions).

The causes includes differences in

1.Laser alignment between CT and linear accelerator.

2.CT couch longitudinal positional indication.

3.image resolution.

4.margin growing algorithm.

5.Field edge and MLC leaf position.

6.isocentre location.

7.source to surface distance indication.

8.gantry and collimator angle accuracy.

They are corrected by quality assurance by adequate routine check outs.We should ensure that any differences lie within +/-2mm for a distance +/- 1 degree for angle indication.

Patient setup error:

Causes include:

1.change in patient position.

2.change in shape or size(eg..weight change,hair loss)

3.Movement of target relative to skin marks caused by CT scan and treatment performed on different treatment couches

It is the only one possible part of overall systematic setup error.

RANDOM ERROR:

It is a deviation that can vary in any direction and magnitude for each delivered fraction of treatment.`

It is classified into individual and population random errors.

Individual:

It is the standard deviation of the measured errors during the delivery of treatment in each fraction.

Population random error:

It is calculated for group of patients as the mean of individual random errors.It usually occurs at treatment delivery stage and hence called execution errors.

Types of random errors:

1.Patient setup error:

They are unpredictable changes occurng from change in patients position.,treatment machine and setup difference between each delivered fraction.

2.Target position and shape:

It accounts for motion between the treatments rather than from delineation to treatment.

3.Intrafraction errors:

Its the change in the patient position and internal anatomy arising during delivery of single fraction eg:breathing

Offline correction strategy may not predict the random error part in subsequent fractions and hence treatment margins must be calculated to include these variations.

The individual mean set-up error is the mean set-up error for an individual throughout the treatment regimen and is calculated as the ratio of the sum of the measured set-up errors for each fraction to number of imaged fractions. It can be expressed by the formula:

$$m_{individual} = \frac{\Delta_1 + \Delta_2 + \Delta_3 + \ldots\ldots + \Delta_n}{n}$$

Overall population mean for the analyzed group of patients is a strong indicator of any given treatment technique and it should be ideally zero. It is calculated as the ratio of sum of the mean errors of the individuals of the group to the number of patients in the analyzed group. It can be expressed using the following formula:

$$M_{pop} = \frac{m_1 + m_2 + m_3 + \ldots\ldots + m_p}{P}$$

Population systematic error is defined as the standard deviation of the individual mean set-up errors about the overall population mean. It's calculated as the square root of ratio of the sum of the squares of the differences between the overall population mean and individual patient mean to the total number of patients minus one. It can be expressed as follows:

$$\sum\nolimits_{set\text{-}up}^{2} = \frac{(m_1 - M_{pop})^2 + (m_2 - M_{pop})^2 + (m_3 - M_{pop})^2 + \ldots + (m_n - M_{pop})^2}{(P - 1)}$$

The individual random set-up error is a measure of the standard deviation of the setup errors around the corresponding mean individual value. It is calculated as square root of the ratio of sum of the squares of the differences between the mean individual error and the set-up error from each image in turn to the total number of images minus one. Mathematically expressed as:

$$\sigma^2_{individual} = \frac{(\Delta_1 - m)^2 + (\Delta_2 - m)^2 + (\Delta_3 - m)^2 + \ldots + (\Delta_n - m)^2}{(n-1)}$$

Population random setup error is the mean of all the individual random errors. It is calculated as the ratio of sum of all the individual random errors to the total number of patients assuming that all patients are imaged similar times.

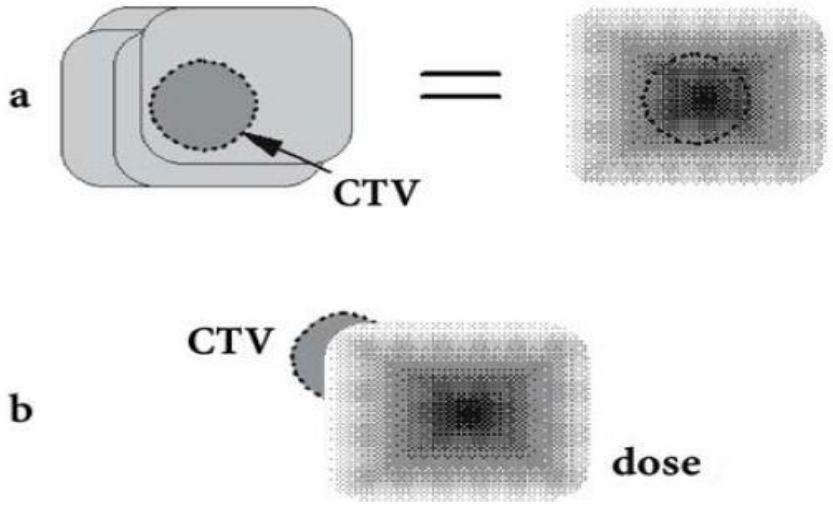
It is mathematically expressed as:

$$\sigma_{set\text{-}up} = \frac{\sigma_1 + \sigma_2 + \sigma_3 + \ldots + \sigma_p}{P}$$

Diagram of the impact of geometrical deviations on dose distribution:

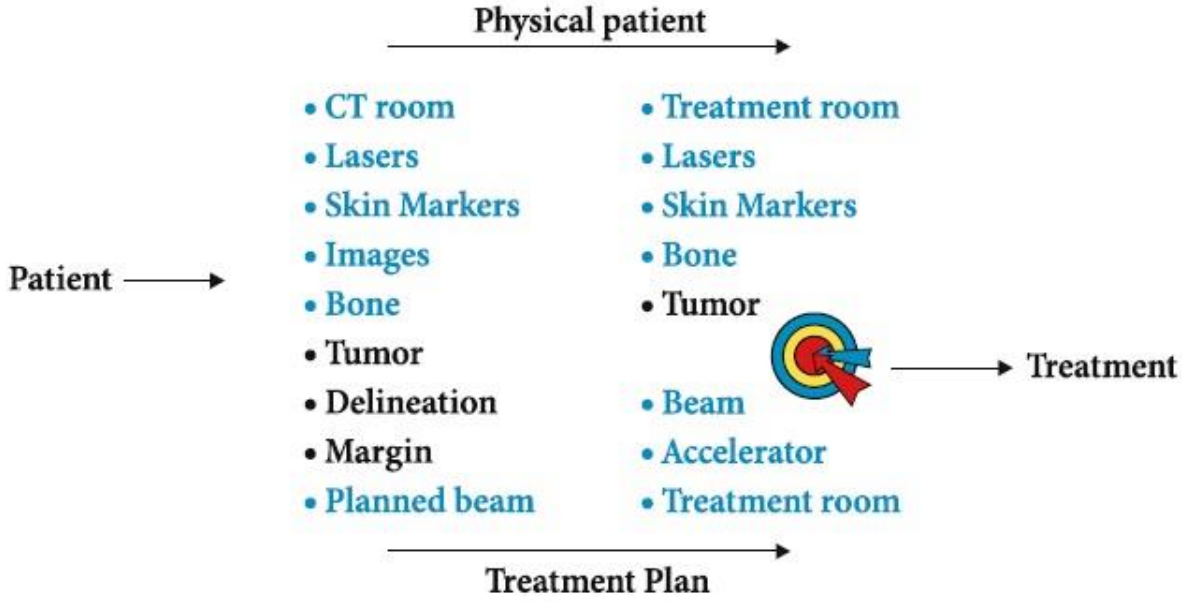
(a) random errors lead to blurring of dose distribution

(b) systematic errors lead to shift of the cumulative dose distribution relative to CTV



WORKFLOW OF RADIOTHERAPIC CHAIN-STEPS

CHECKED WITH EPID



Measurement of Geometrical Errors and its Correction:

Geometrical errors measurement is important for definition of margins. The more important one to correct is systematic error because it has more effect on magnitude.

1.Target volume delineation – It is measured by multi-observer studies and is reduced by clear protocols such as RTOG, training and consultation and multi-modality imaging without relying on single modality image information .

2.Organ motion:

Tumor motion is measured by CT ,markers detected through X ray,EPID.USG and CBCT are alsoused recently for tracking of tumor.We can correct this by gating,good treatment and CT scan protocols.The most effective way to reduce this is adaptive radiotherapy using daily online imaging for atleast first few fractions which helps in achieving smaller systematic errors.

3.Setup errors:

Portal imaging helps in reducing setup errors.For this portal image is compared with simulation image and matching should be done.Best way is compare DRR with portal image.Bony landmarks kept as guidance and matched with DRR.On line and offline review should be done and errors are measured and corrected.

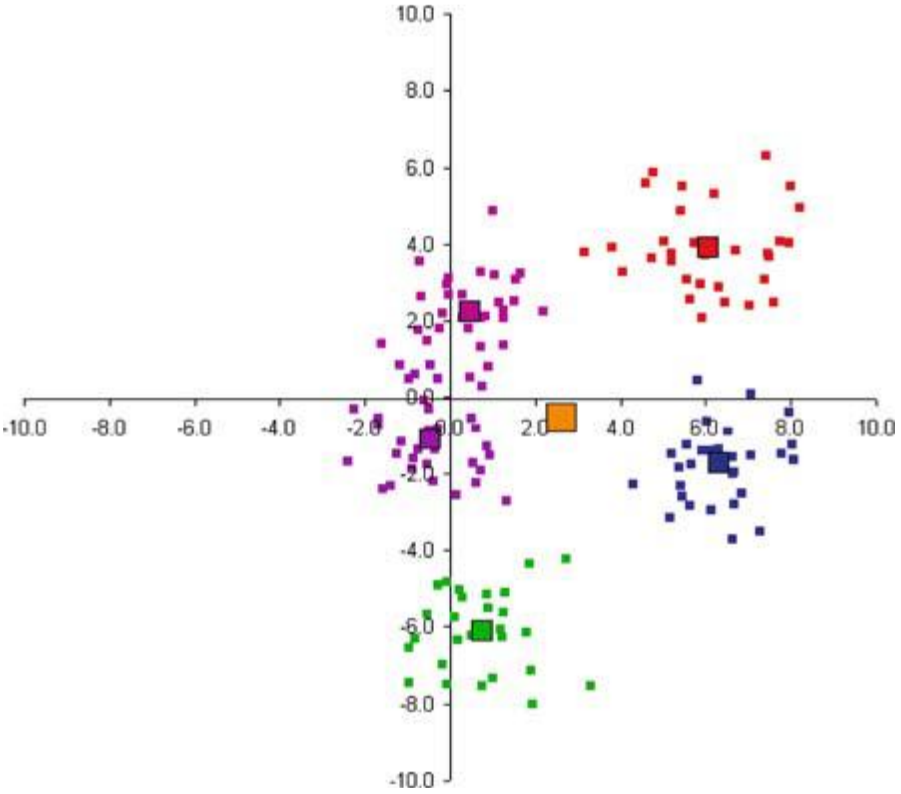
Random and systematic errors.

Each group of points represents the fractions of single patient.

The scatter within a group is day-to-day variation.

The group average (the five larger squares) is the systematic error of a patient.

The mean of all patient averages is indicated by the large yellowish orange square and this is the overall mean.

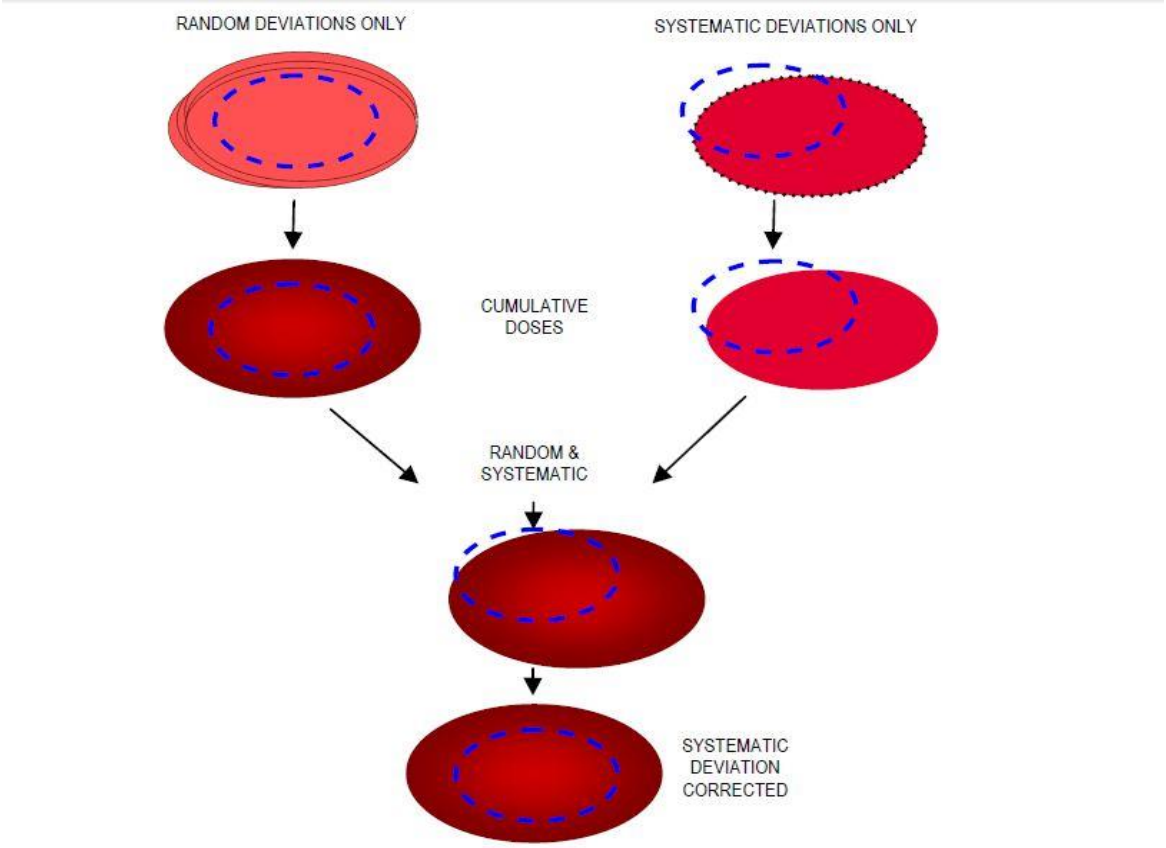


The effect of setup displacement on the dose distribution relative to CTV.Random deviations leads to a blurring of the dose distribution.systematic deviations lead to shift in the dose distribution relative to the CTV.

If uncorrected the systematic error remain throughout the course of treatment thereby compromising dose coverage to the CTV.

Verification is needed to ensure that systematic displacement lies within tolerance levels.

Offline review corrects systematic errors during treatment and only remaining thing is random error.



HOW TO CREATE GEOMETRIC VERIFICATION PROCESS:

The verification process should consider

1.Personnel,responsibility and training.

2.Equipment and technical infrastructure.

3.Imaging protocols

-Imaging

-Frequency ,time of imaging.

4.Measurement of setup errors

-systematic error

-Random error

5.Action levels,Tolerances and correction strategy.

6.For concomitant exposure dose measurements should be considered.

EQUIPMENT AND TECHNICAL INFRASTRUCTURE:

1.Images should be in good quality and to be able to give information needed.

2.Effcective connectivity is needed.

3.Clear conventions are required for coordinatings system and error reporting.

4.Good quality assurance .

5.Uncertainities in verification process should be calculated.

6.For good complete verification process suitable software must be used.

PERSONNEL,RESPONSIBILITIES AND TRAINING:

1.To set guidelines on structure and process a good verification team is requireds .

2.Assessment of training and competency are required.

3.For an each institute a risk analysis should be done.

IMAGING PROTOCOLS:

1.Image acquisition depends on quantity of satble anatomy seen within the field.

2.Timing of image acquisition should be ideal.

3.Atleast two orthogonal images are required to verify image in all directions.

4.To assess systematic error for radical treatment atleast three to five imaging sets are needed..

5.Site and treatment technique decides number of fractions to be imaged.

MEASUREMENT OF SETUP ERRORS:

1.Prior to first treatment gross error should be detected.

2.Individual ssystematic setup error should be calculated and minimized.

SUMMARY,TOLERANCES,ACTION LEVELS AND CORRECTIVE STRATEGIES:

1.Gross errors musts be corrected as soon as possible.

2.Radiotherapy department in each institute have to evaluate their tolerances

3.Tolerances used in imaging protocol depends on

a.Anatomical site

b.The technique of treatment.

c.CTV-PTV margin.

d.At last the compliance of the patient.

4.What are the action to be taken in treatment verification:

a.Further repeat imaging it was a simple random error.

b.Systematic error reassessment.

5.Corrective strategies:

a. Needs accurate calculation of systematic setup error.

b.Then the choosed correction strategy should be applied to remove the error.

c.Corrections applied to treatment setup must be verified.

d.Weekly imaging is necessary.

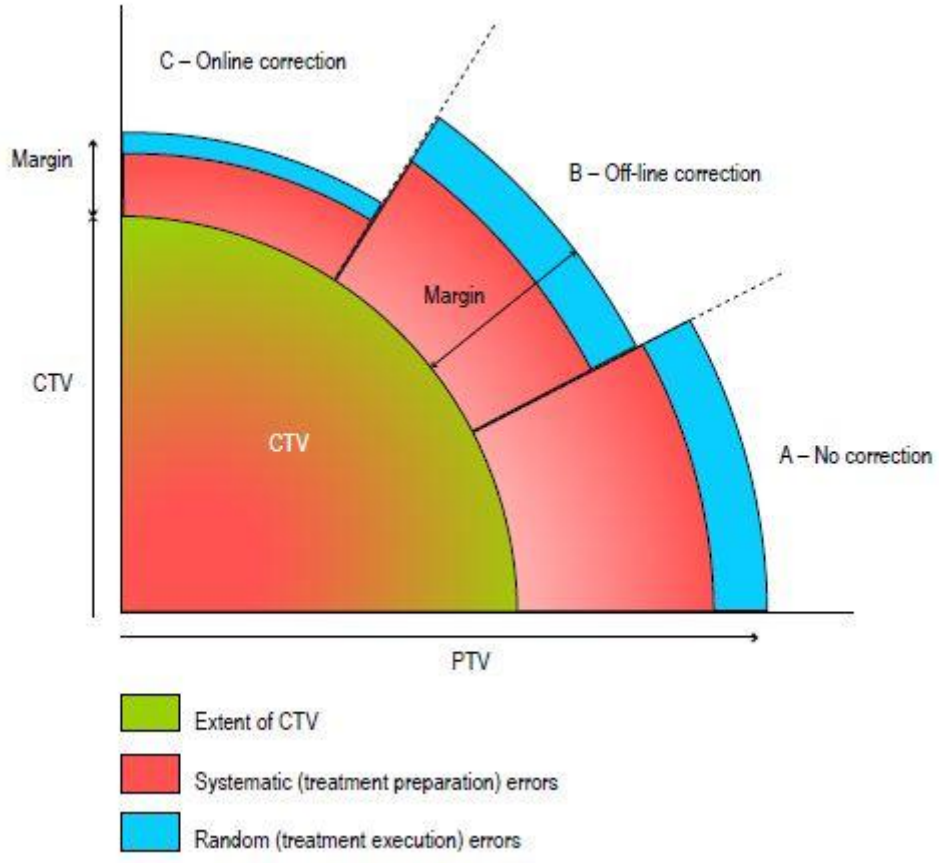
DOSE CONSIDERATIONS:

a. Dose accumulation due to concomitant exposures and treatment accuracy using imaged information should be optimized.

b.It is better to setup and image correctly for ensure adequate and accurate coverage of target volume and to avoid risk associated with additional exposure.

RELATIONSHIP BETWEEN CTV-PTV TREATMENT MARGIN AND TREATMENT VERIFICATION

CTV-PTV margins is influenced by both systematic and random errors. Using online imaging treatment is verified and quantified to reduce sources causing errors and to reduce applied applied margin.



APPROPRIATE PROTOCOL FOR HEAD AND NECK VERIFICATION:

On fraction 1-Before starting treatments:

1.Orthogonal images to be taken to minimize dose to the critical structures.

2.Acquire images for all possible treatment fie;ds ifd field edge verification is needed.

3.Verify and correct gross errors immediately**.**

On fraction 2 and 3

To take orthogonal images and assess each image against tolerance level set and correct gross errors.

Action before fraction 4

1.Calculate systematic error in AP,SI,ML directions.

2.If setup error is more than the action level we have to apply systematic setup error correction.

Fraction 4 and 5

If setup is corrected then do repeat imaging**.**

If practical then calculate the new overall systematic setup error and correct values greater than action level.

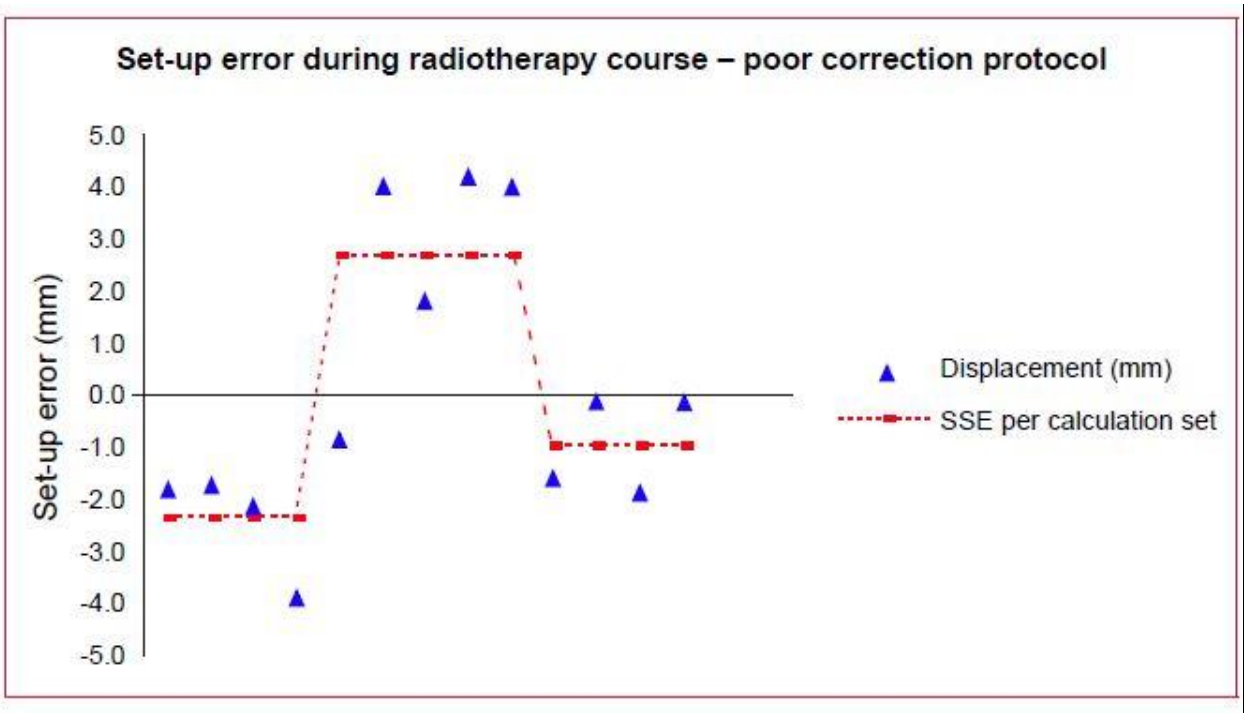
Weekly and first day of each phase of treatment plan:

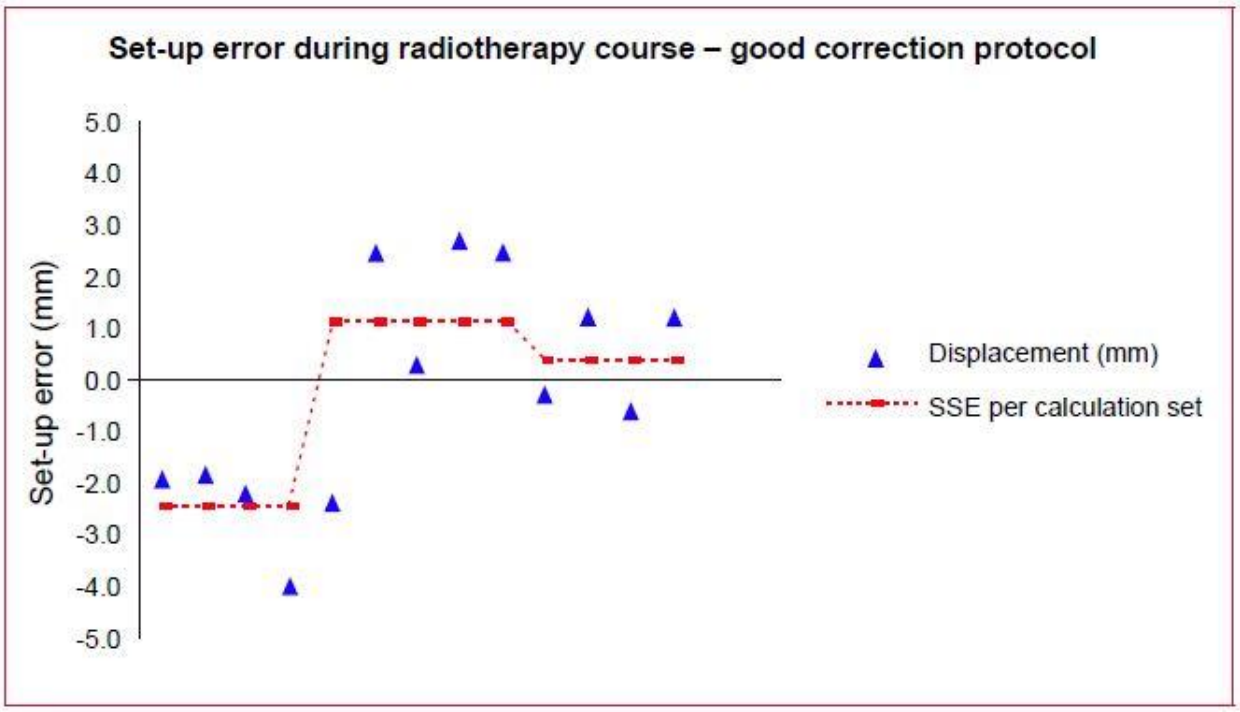
1.To take orthogonal image each week.

2.Correct gross errors for each fraction whenever necessary.

3.If setup error significantly differs then do repeat imaging.

4.Apply systematic setup error correction if needed**.**





OTHERS:

***Immobilisation is strictly neccessary.

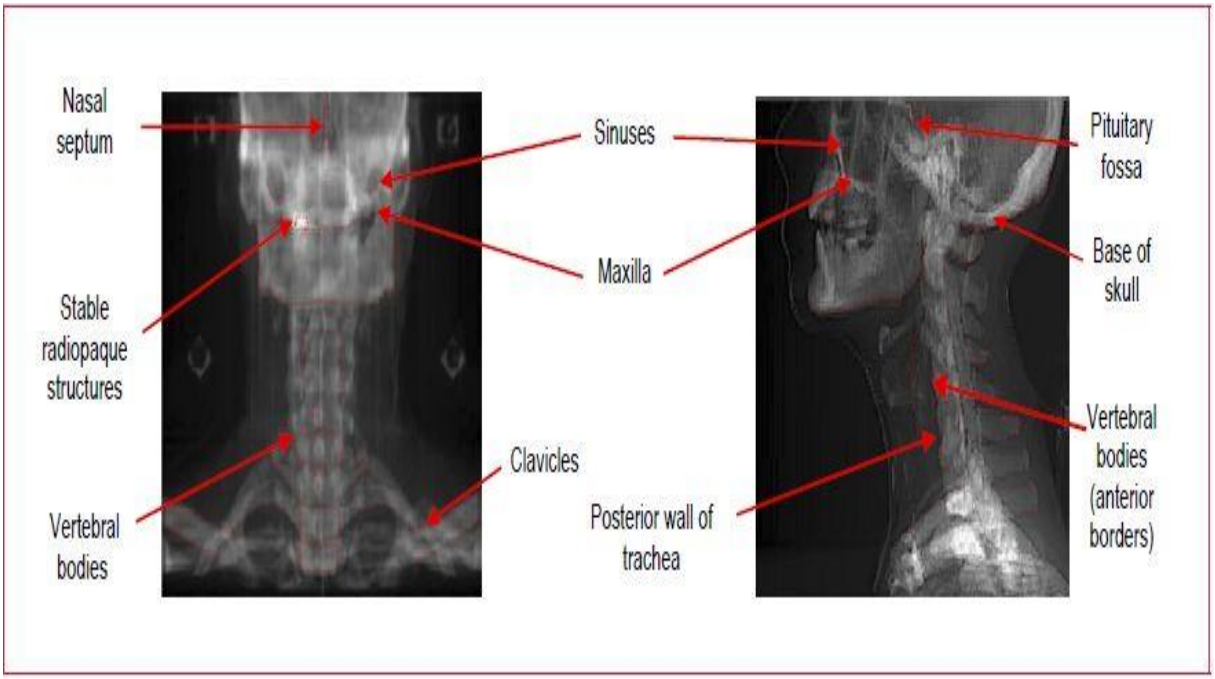
*Impact of organ motion of tongue and larynx considered.

*Isocentre should be verified using anterior,posterior and lateral views.

*Bony anatomy should be clearly taken in the images taken.

*Tumors planned with very small margins or hypofractionated treatment are daily verified with images**.**

ANATOMIC STRUCTURES SHOULD BE MATCHED:



EVIDENCE FOR HEAD AND NECK TREATMENT VERIFICATION GUIDELINES:

IMMOBILISATION AND APPROPRIATE SPATIENT POSITIONING:

a)Low and high melting point thermoplastic masks.

b)Bite blocks.

Tumor shrinkage and weight loss leads to change in patients anatomy and ill fitting immobilization device over the course of treatment**.**

GTV decreases by 1.8% if there is large nodal mass at the start of treatment.

These patients should be considered for remoulding and replanning at 3rd or 4th week of treatment .

SETUP REPRODUCIBILITY:

More effective immobilization produces good setup reproducibility.Moulds should not be used immediately after preparing because there is shrinkage of 2mm in the first 24 hours.

If the field covers the lower neck and supraclavicular fossa shoulders should be matched exactly where more differences occur.

4)ANATOMY

OROPHARYNX:

Anteriorly-oral cavity.

Postoinferiorly-larynx and hypopharynx.

Superiorly -nasopharynx.

Subsites:Tonsil,Base of tongue,soft palate.

Tonsil-consists of anterior and posterior tonsillar pillar between them there is cleft where palatine tonsil is located.

Base of tongue-comprises of posterior 1/3 of tongue

Borders-Anetrior-circumvallate papillae in front of sulcus terminalis.

Posterioinferior-hyoid and epiglottis.

Laterally-glossopharyngeal sulci.

Lingual tonsil present under base of tongue.

Vallecula- is a 1 cm mucosal strip between base of tongue and epiglottis.

Sensory innervation of the base of tongue is glossopharyngeal nerve.

Soft palate-fibromuscular structure

Boundaries:

Anterior-hard palate.

Lateral-anterior tonsilar pillar

Midline-uvula.

Posteroinferior-free edge.

Components of soft palate-levator veli palatini,

palatoglossus,palatopharyngeus,musculus uvulae.

Muscles of soft palate supplied by pharyngeal plexus**.**

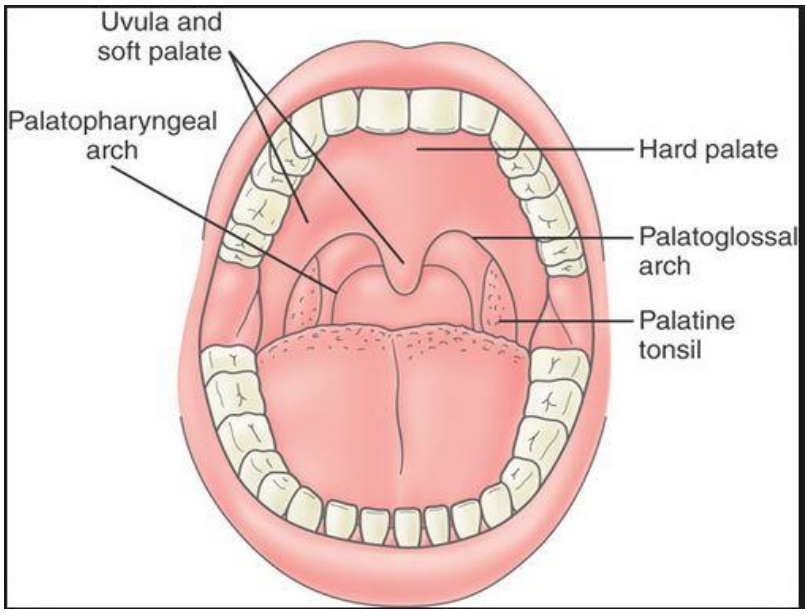
Lymphatic spread:

Most common-ipsilateral level II.

Order of metastatic progression:

Level I/II superiorly → midcervical(level III) → lower cervical(levelV) inferiorly..

ANATOMY OF OROPHARYNX



HYPOPHARYNX

Behind the Larynx (in front of 3rd to 6th Cervical vertebra) From the tip of epiglottis superiorly to the lower border of cricoid cartilage inferiorly

Communicates: - Anteriorly with the Larynx ,Superiorly with the oropharynx Inferiorly with the esophagus

The hypopharynx does not only lie behind the larynx but also Projects laterally on each side of the larynx So it is formed of : Postcricoid region (behind the larynx) - Two pyriform fossae and posterior pharyngeal wall.

PYRIFORM SINUS

Shape : inverted pyramid.

Extent: -Superiorly: epiglottis .

Lateral: thyroid cartilage

Medial: arytenoid cartilage; aryepiglottic fold.

Posteriorly: open & continuous with posterior pharyngeal wall.

Apex: meeting of anterior, lateral &medial wall inferiorly

POST CRICOID REGION

Pharynx mucosa covering post. Surface of cricoid

Pharynx become continuous with esophagus at post cricoid region

Extent:

Superior: arytenoids

Inferior: oesophagus

POSTERIOR PHARYNGEAL WALL

Cover middle & inferior constrictor muscles.

Separated from prevertebral fascia by retropharyngeal space.

Extent: Superiorly: upper border of epiglottis

Inferior: lower border of cricoid

Sideways: apex of one pyriform sinus to other.

Nerve supply of hypopharynx

Internal branch of superior Laryngeal nerve :vagus(X)

Glossopharyngeal nerve :(IX)

sensory: External branch of superior Laryngeal nerve (X) Recurrent laryngeal nerve (X) Pharyngeal plexus (IX) motor

LYMPHATIC DRAINAGE

Deep cervical lymph node : level 2,3& 4

Prelaryngeal & paratracheal lymph nodes: level 6.

Retropharyngeal node -Node of rounviere at skull base.

POST CRICOID AREA: The hypopharynx leading to upper oesopageal sphincter. Occasionally brisk opening seen apon laryngeal examination . Upper osophageal sphincter opening- upon rigid oesophagoscopy.

CARCINOMA HYPOPHARYNX

Constitute 5.2% of upper aerodigestive tract cancer.

Mostly squamous cell carcinoma of hypopharynx.

Mean age of presentation 65 years

Common stage of presentation : stage III& IV -POOR PROGNOSIS

INCIDENCE OF HYPOPHARYNX CARCINOMA.

65-75%-pyriform sinus carcinoma

5-15% - post cricoid carcinoma.

10-20% -posterior pharyngeal carcinoma.

RISK FACTORS OF CARCINOMA HYPOPHARYNX

Age & Sex: carcinoma pyriform fossa- male above 40 years

Carcinoma postcricoid region: females 20 to 40 years

Carcinoma posterior pharungeal wall : males above 50 years

Family history -Tobacco ,Alcohol

Exposure : polyaromatic compounds ; asbestos & welding fumes

Nutritional deficiency. VIT A & E. iron, Carotenoids and flavenoids.

RISK FACTORS OF CARCINOMA HYPOPHARYNX

infections; HPV (20–25% only postive for HPV DNA & Ab against HPV 16 E6 & E7)

Associated diseases: PLUMMER VINSON SYNDROME

GENETIC: P53 & EGFR mutation -Synchronous & metachronous malignancy.

FIELD CANCERIZATION

Hypopharynx Carcinoma occur within field of diseased mucosa .Carcinogens induce dysplastic changes in mucosa of the upper aero digestive tract. Increased risk of malignancy

CARCINOMA OF PYRIFORM SINUS

Age:40 years

presentation: late; Metastatic neck nodes

Spread: local Upwards: base of tongue Downwards: post cricoid region Medially: AE fold and ventricle Laterally: thyroid cartilage, -Lymphatic spread: upper and middle group of jugular cervical nodes -Distant metastasis: occur late and may be seen in lung, liver, bone

CARCINOMA OF POST CRICOID REGION

Plummer-Vinson syndrome age group of 20-40; female Progressive dysphagia Voice change Weight loss

Spread: local spread - cervical oesophagus, arytenoids

Lymphatic spread - paratracheal nodes, may be bilateral due to midline nature of lesion

CARCINOMA OF POSTERIOR PHARYNGEAL WALL

Mostly seen in males above 50 years of age

Clinical features: dysphagia, metastatic neck node

Spread: local - prevertebral fascia, muscles and vertebrae

Lymphatic: usually bilateral, retropharyngeal and deep cervical nodes involved

CLINICAL PRESENTATION

Hoarseness of voice: vocal cord fixation

Stridor: mass effect on trachea

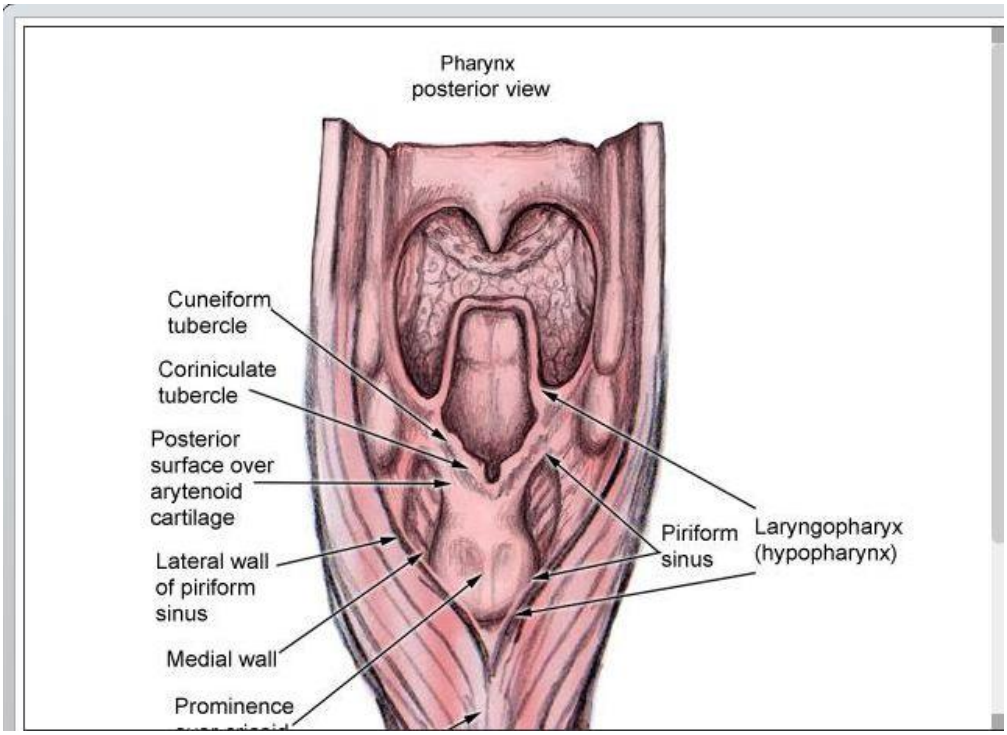
Weight loss. Anemia, malnutrition, Throat pain, Sore throat dysphagia

Odynophagia ,pooling of saliva

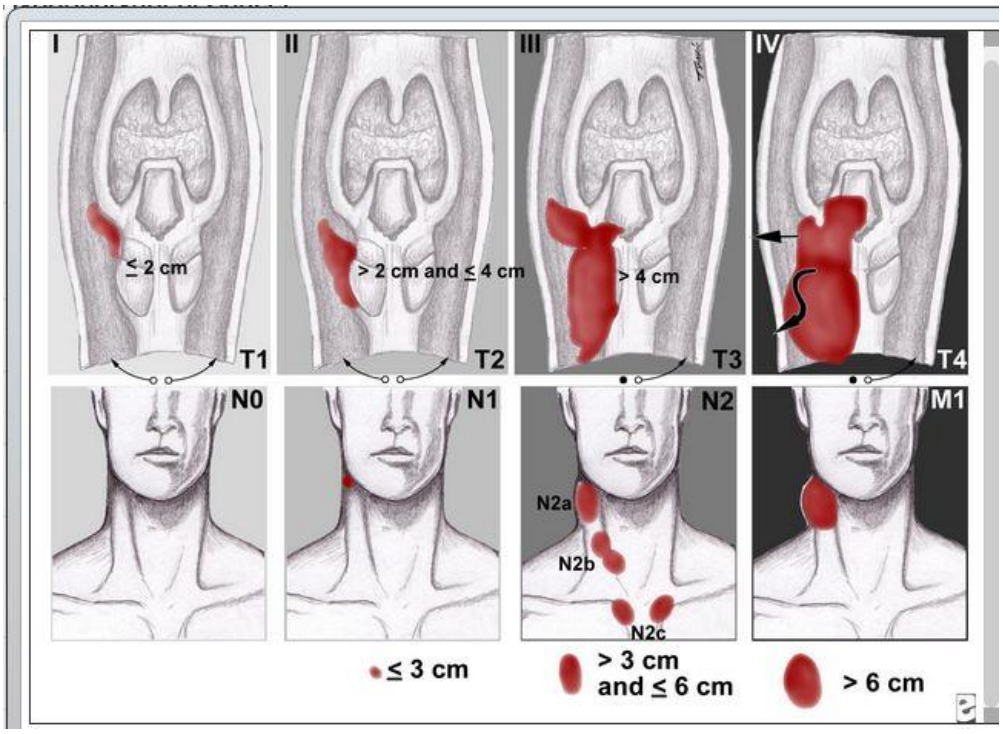
Referred otalgia: cause int. laryngeal nerve (X) Neck mass: metastatic neck node

Direct extension most frequent presenting symptoms include a neck mass (either representing the tumour or nodal metastases .

ANATOMY OF HYPOPHARYNX



STAGING OF HYPOPHARYNGEAL CANCER:



CLINICAL EVALUATION

History taking

General physical examination

Oral hygeine & dentition

Airway status

Status of speech & swallow.

Complete examination of oral cavity , oropharynx.

Examinaton of neck nodes.

Indirect layngoscopy

Direct laryngoscopy

EXAMINATION OF NECK NODES

Location ,Size ,number ,Mobility ,Tenderness ,Relationship with adjacent structure.

Examination of neck nodes: sub mental(Ia) & submandibular(Ib)

Examination of neck nodes: upper.,middle & lower deep cervical (ii; iii. iv)

INDIRECT LARYNGOSCOPY -mirror warmed; check temp. -Hold tongue - Introduce mirror into the oral cavity facing downwards - mirror brought to rest against the uvula -do not touch the posterior pharyngeal wall - laryngeal inlet is visualized,

Structures seen on indirect laryngoscopy (in order):

Base of the tongue ,Vallecula ,Median and lateral glossoepiglottic folds

Epiglottis ,Vestibular fold ,True vocal cords ,Trachea ,Layngeal cartilage

PRE TREATMENT EVALUATION:

To asses extent of tumor Relation with other structure Involvement of larynx

Mobility of vocal cords

Direct laryngoscopy

Oesophagoscopy

Bronchoscopy

Panendoscopy

Chest x ray :infection; malignancy;metastasis

HRCT : thickness, invasion, L.N metastasis

MRI :soft tissue details, tissue edema

PET :residual or recurrent tumor after RT

NASOPHARYNX:

It is a cuboidal chamber.

Boundaries:

Anteriorly:continuous with nasal cavity via posterior choanae**.**

Inferiorly-oropharynx.

Roof-basilar portion of sphenoid and occipital bones.

Floor-superior surface of soft palate and nasopharyngeal isthmus.

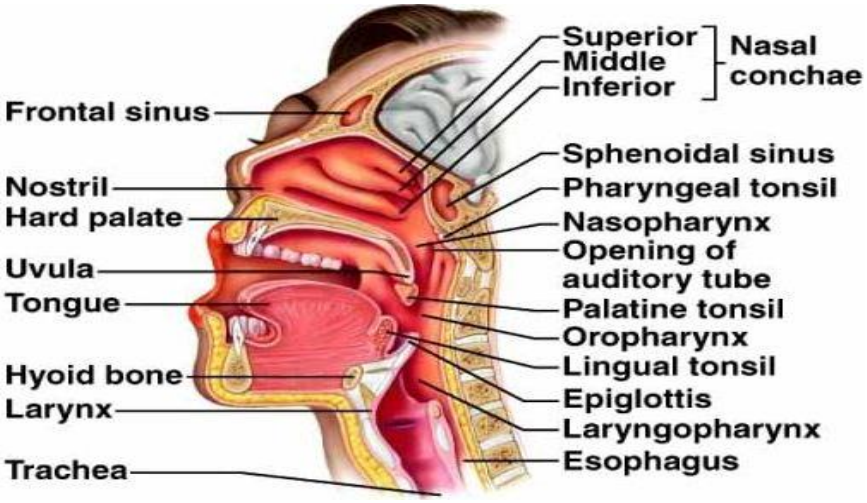
Lateral- Eustachian tube

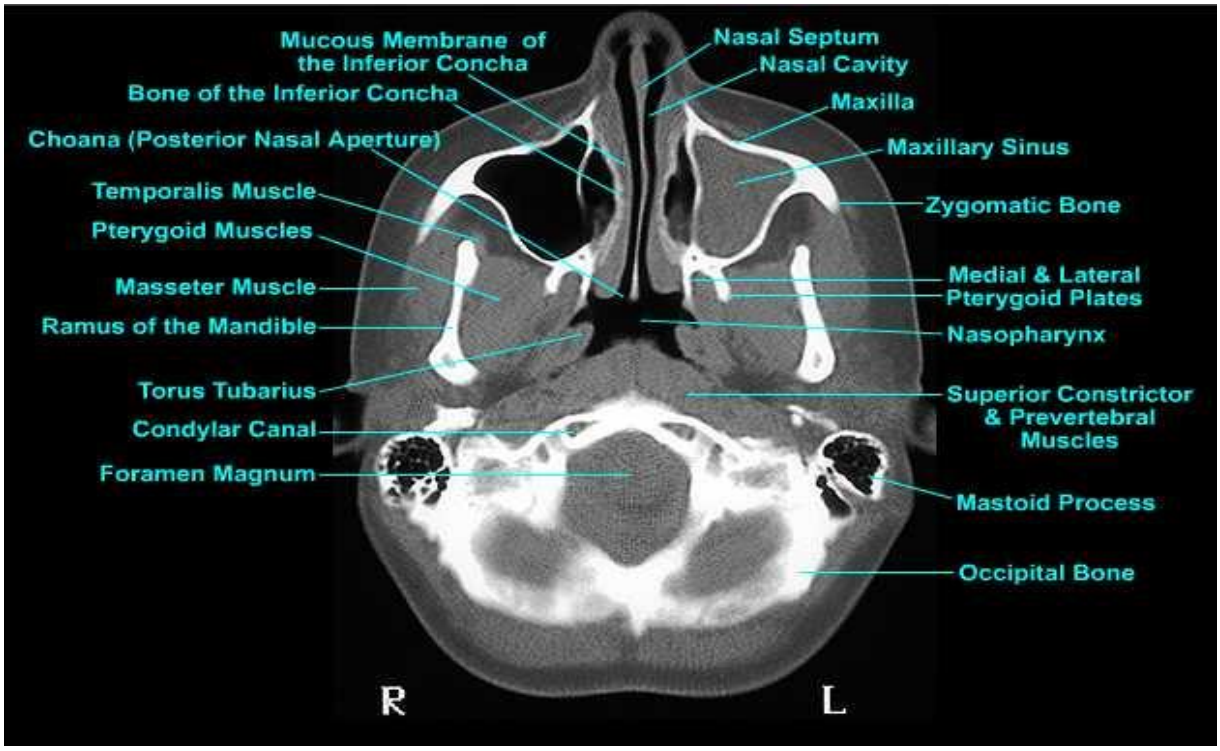
Lateral wall contains fossa of rosenmuller –most common origin of malignancy.

Nerve supply-sensory-maxillary division of trigeminal nerve and glossopharyngeal nerve.

Motor-glossopharyngeal nerve,vagus nerve and sympathetic fibres from superior cervical ganglion.

ANATOMY OF NASOPHARYNX





REVIEW OF LITERATURE:

BMF such as body weight, body height, and the circumference and bilateral thickness of the neck of patients were taken from the online Kilo-voltage CBCT acquired using the on-board imager and assessment of setup errors by systematic error (SE) and random error (RE) through the superior-inferior (SI), anterior-posterior (AP), and medial-lateral (ML) directions, and couch rotation (CR). The magnitude of the effect of BMF could be calculated using Mann–Whitney U test. Among the ratios of the BMFs during radiotherapy, the values at the level of mastoid tip at the 20th fraction were associated with greater setup errors.

Deviation between intended geometry of radiotherapy plan and real geometry of radiotherapy treatment were presented as geometrical errors.Buildup of smaller

errors, which can be generally classified as set-up, organ motion, organ delineation, and technical condition related errors is the total geometrical error. The amount of systematic and random component of these errors should be encountered in treatment planning process and a clear distinction must be made between them. The amount of most of geometrical errors can be predicted, minimized, and kept under control if errors are measured with EPID and proper correction strategy are deployed; the precision of treatment and consequent results can also be improved.

IMRT treatments are more sensitive to setup errors and so taking into account the systematic errors in treatment plans. A planning margin to account for set-up errors was added to the clinical target volumes and to the spinal cords and the part of the target covered with a dose >95 and <105% and the effect in the critical organs is dependent on the sharpness of the dose gradients outside the critical organ thereby it is plan quality dependent too.

The setup displacements and translational and rotational errors were taken into account from the online images acquired prior to treatment and based on that individualized margins for CTV, PTV was generated.

II)OBJECTIVE AND METHODOLOGY:

1)AIM OF THE STUDY:

To analyse the impact of body mass factors before radiotherapy and changes occurring during radiation leading to setup displacement in patient with head and neck cancers and need of replanning.

2)OBJECTIVE

Primary objective:

By assessing degree of setup error and effects of Body Mass Factors on setup errors we can analyse the need of replanning and to assess whether these factors are really helpful in replanning and Adaptive radiotherapy .

Secondary objective:

1.TCP/NTCP ratio calculation .

2.Change in Body mass factors and need of replanning.

3.Impact of replanning

Sample size: 50.

Study design:Prospective

Study period: December 2014-October 2015.

Inclusion criteria:

All patients with

1. Age >30 years.
2. Both sexes
3. Sites included-Nasopharynx,oropharynx,hypopharynx.
4. Patients planned for definitive Chemoradiation/definitive radiation.
5. ECOG performance status-0-2
6. Informed consent from patient.

Exclusion criteria:

1. Patients with poor performance status.
2. Patients initially treated outside.
3. Patients who had initial surgery.
4. Patients with palliative intent treatment.

3)Methods and Materials:

Methods of Planning:

1.Patients are immobilised with thermoplastic mask.

2.CT for RT planning done from Orbit to shoulder with 3mm cuts

3.Marks like leadshot are placed over patients surface using laser to facilitate accurate daily position.

4.For patients receiving definitive radiation CTV was defined as GTV+1-1.5cm margin.Guidelines for delineation of elective nodal CTV were followed.PTV was extended 3mm around CTV.

5.IMRT plans are generated.

6.Prescription dose will be 54 Gy to CTV and boost to high risk regions primary and involved lymph nodes of about Total dose 66 Gy.

Method of Treatment verification:

1.Patients are postioned on the couch according to reference marks already kept during planning.

2.Online On board imaging (2D KVCT daily and 3D CBCT at 10 th and 20 th fraction)were taken and registered with Digitally reconstructed radiographs from the treatment planning images.

3.Images are compared by correlation of bony anatomy and differences are corrected by shifting couch translationally before treatment.

4.Atleast 3 reference landmarks included-3 visible bony landmarks:

1.Vertebra of Cervical Spine.2.Nasal septum.3.Mandible profile.

Anthropometric Measurements of Body related Factors:

Patient related Factors:

1.Performance score.

2.Age

3.Body mass factors.

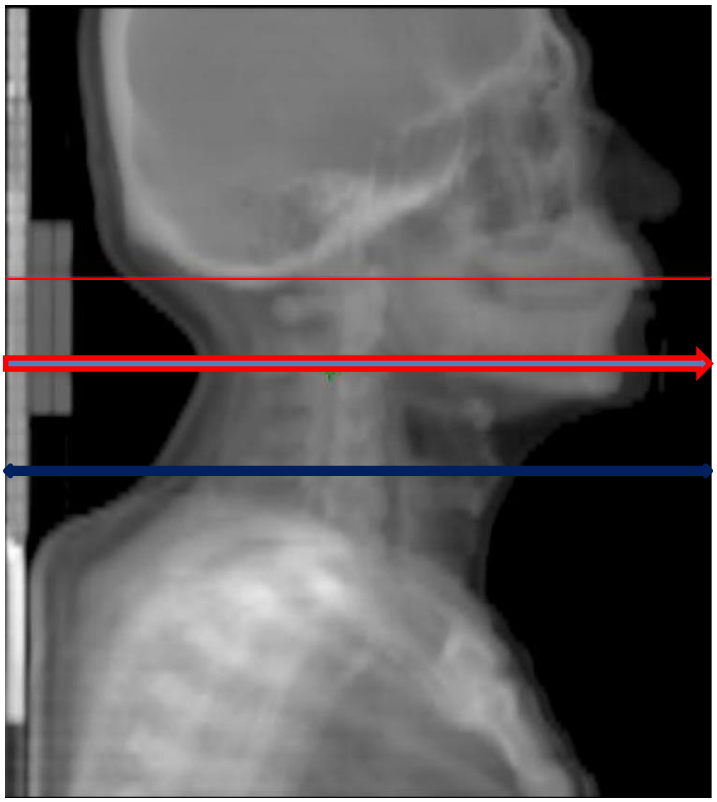
4.Performance status:Scored according to ECOG.

5.Body mass factors included are a)BMI b)Circumference and thickness across three specified sections of head and neck.

Level A-Line drawn at level ofMastoid tip ,same section as the junction between skull base and 1 st cervical vertebra.

Level B –Line drawn based on mandible angle,same height as the junction between 2nd and 3 rd cervical vertebra.

Level C-Line drawn at level of thyroid notch ,same as the 5 th cervical vertebra.



Level A

Level B

Level C

3.Body mass factors will be recorded before RT and at 10^{th} and 20 th fractions during course of radiation.

4.Circumference and thickness values are retrieved from CT simulation images and Cone beam CT images at three specified levels during treatment.

5.Circumferences are calculated by brushing body contour at specified section with fixed thickness to generate volume,and then calculated volumes are divided by the contouring thickness to get the values of circumferences.

6.Thickness is calculated as the maximal transverse distance at same distance as circumferences.

7.Body mass index was calculated by dividing weight in kilograms by height in metre square.

8.Patients are monitored weekly and toxicities are recorded according to CTCAE.

9.Ratio of BMFs during RT are calculated at three levels.

Ratio of Circumference at n th fraction =

$$\frac{\text{Cirumference at level A at n th fraction}}{\text{Pretreatment Circumference}}$$

Patient characteristics before radiotherapy

Number	Variable	Values
1.	Age(years) Median	 54 years
2.	Weight(kg) Mean Median	 56.5 years 54 years
3	Height(cm) Mean(range) Median	 164.4 cm 165 cm
4	BMI Mean(range) Median	 23.2 22.8
5	ECOG PS 0 1-2	 24 26
6	CCRT/RT alone CCRT RT alone	 41 9

7	Tumor site Oropharynx Hypopharynx nasopharynx	 18 29 3
8	Circumference A(cm) Mean ±SD	 48±2.6
9	Thickness A Mean ±SD	 15.1±1.2
10	Circumference B(cm) Mean ±SD	 42±2.8
11	Thickness B(cm) Mean ±SD	 13.2±1.4
12	Circumference C(cm) Mean ±SD	 37±4.2
13	Thickness C(cm) Mean ±SD	 11.5±1.6

Set Up Displacement:

Daily on board image taken and an offline image review should be done and setup errors are calculated in Anteroposterior,mediolateral,Superoinferior directions.s

For each direction systematic and random errors calculated.

Systematic error was the deviation between simulated patient position and average treatment position.Random error occurs between different fractions.By analysing all the alignment data before 25 fractions of treatment for every patient ,values of systematic and random errors for all AP,SI.ML directions are calculated.

Stastical Analysis:

1.To determine the correlation between magnitude of errors and patient related factors are classified into two groups and .calculated using Mann-whitney U test.

2.To examine association between the reduction ratio of body weight and circumferences or thickness,displacement in different direction Pearson correlation coefficient is used.

AP-ANTEROPOSTERIOR	ML-MEDIOLATERAL
SI-SUPEROINFERIOR	SE-SYSTEMATIC SRROR
RE-RANDOM ERROR.	CR-COUCH ROTATION

Setup Errors (mean ± standard deviation in mm) in AP,SI,ML directions according to low range and high range 50% percentile of body mass factors before RT

variable	AP-SE	AP-RE	SI-SE	SI-RE	ML-SE	ML-RE
Weight						
Lower	0.8±0.4	0.8±0.2	2±0.8	1.1±0.3	1.7±0.7	1±0.2
Higher	1.2±0.5	0.8±0.2	2.3±0.9	1.7±0.8	1.8±0.5	0.9±0.3
P value	0.045*	0.250	0.556	0.022*	0.426	0.450
Height						
Lower	1±0.5	0.7±0.3	1.8±0.5	1±0.2	1.7±0.6	1±0.3
Higher	1.2±0.7	0.8±0.3	2.5±1	1.8±0.8	1.8±0.6	1±0.3
P value	0.07	0.15	0.106	0.002*	0.26	0.82
BMI						
Lower	1±0.4	0.7±0.3	2.1±0.9	1.3±0.5	1.6±0.7	1±0.3
Higher	1.2±0.7	0.8±0.3	2.1±1	1.5±0.7	1.9±0.5	1±0.3
P value	0.17	0.506	0.924	0.208	0.304	0.924

Setup Errors (mean ± standard deviation in mm) in AP,SI,ML directions according to low range and high range 50% percentile of body mass factors before RT

Variable	AP-SE	AP-RE	SI-SE	SI-RE	ML-SE	ML-RE
Circumference –A						
Lower	1±0.4	0.7±0.3	2±1	1.3±0.7	1.6±0.8	1±0.4
Higher	1.2±0.6	0.8±0.3	2.3±1	1.5±0.8	2±0.5	1±0.3
P value	0.335	0.485	0.304	0.186	0.344	0.411
Circumference –B						
Lower	1±0.5	0.7±0.3	2±1	1.3±0.7	1.6±0.8	1±0.4
Higher	1.2±0.6	0.8±0.3	2.3±1	1.5±0.8	2±0.5	1±0.3
P value	0.388	0.485	0.304	0.186	0.344	0.411
Circumference-C						
Lower	1±0.5	0.8±0.3	2.2±1	1.3±0.7	1.7±0.7	1±0.3
Higher	1.2±0.6	0.8±0.3	2.1±0.7	1.6±0.7	2±0.5	1.1±0.3
P value	0.47	0.566	0.967	0.334	0.240	0.672
PS						
0	0.9±0.4	0.7±0.3	2±0.9	1.2±0.3	2±0.6	1.1±0.3
1-2	1.4±0.5	1±0.3	2.5±1.1	1.8±1	1.6±0.7	1±0.4
P value	0.042*	0.015*	0.24	0.042*	0.071*	0.933

Setup Error (mean ± standard deviation in mm) in AP,SI,ML directions according to low range and high range 50% percentile of body mass factors during RT (10th fraction)

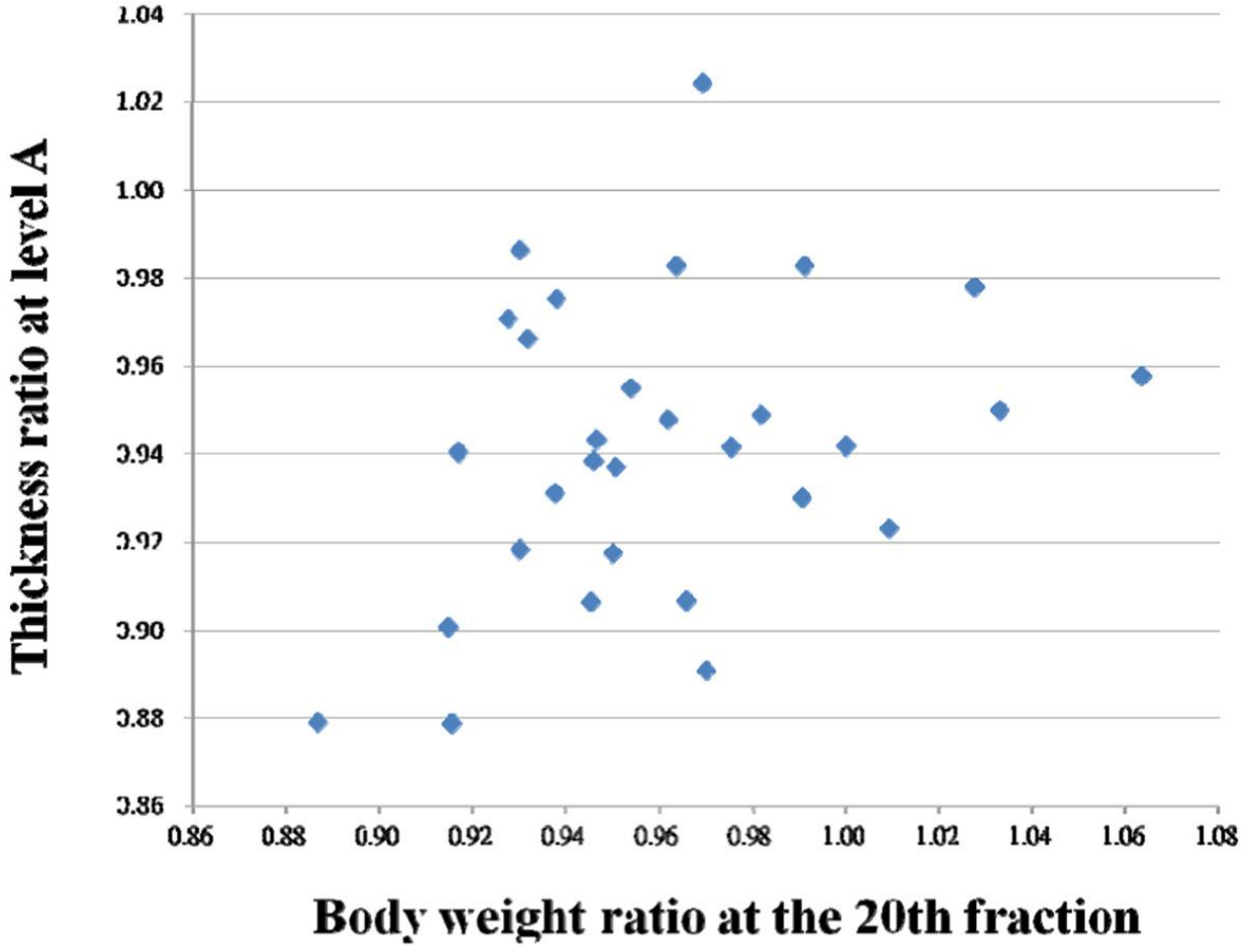
VARIABLE	AP-SE	AP-RE	SI-RE	SI-RE	ML-SE	ML-RE
rT(level A)						
lower<0.98	1±0.5	0.8±0.3	2.3±1.1	1.6±0.8	2±0.5	1.1±0.4
higher>0.98	1.2±0.5	0.9±0.4	2±0.8	1.3±0.7	1.6±0.6	1±0.3
P value	0.184	0.283	0.843	0.421	0.223	0.043*
rT(level B)						
lower<0.97	1±0.5	0.8±0.2	2.1±1	1.3±0.4	1.7±0.7	1.2±0.3
higher>0.97	1.1±0.7	0.9±0.3	2.2±0.9	1.5±1	1.9±0.6	0.9±0.25
P value	0.665	0.917	0.462	0.447	0.324	0.018*
rBW						
lower<0.99	1.1±0.5	0.9±0.3	2±0.7	1.4±0.4	2±0.7	1.1±0.3
higher>0.99	1.1±0.5	0.9±0.3	2.1±1.1	1.4±0.8	1.7±0.5	1±0.3
P value	0.842	0.873	0.808	0.883	0.778	0.256

rT-ratio of thickness.

Bw-Body weight.

rC-ratio of circumference

Association between ratio of weight and thickness at level A during the 20th fraction of CBCT (r = 0.32, p = 0.081).



Setup Error (mean ± standard deviation in mm) in AP,SI,ML directions according to lower and higher 50% percentile of body mass factors during RT (20th fraction)

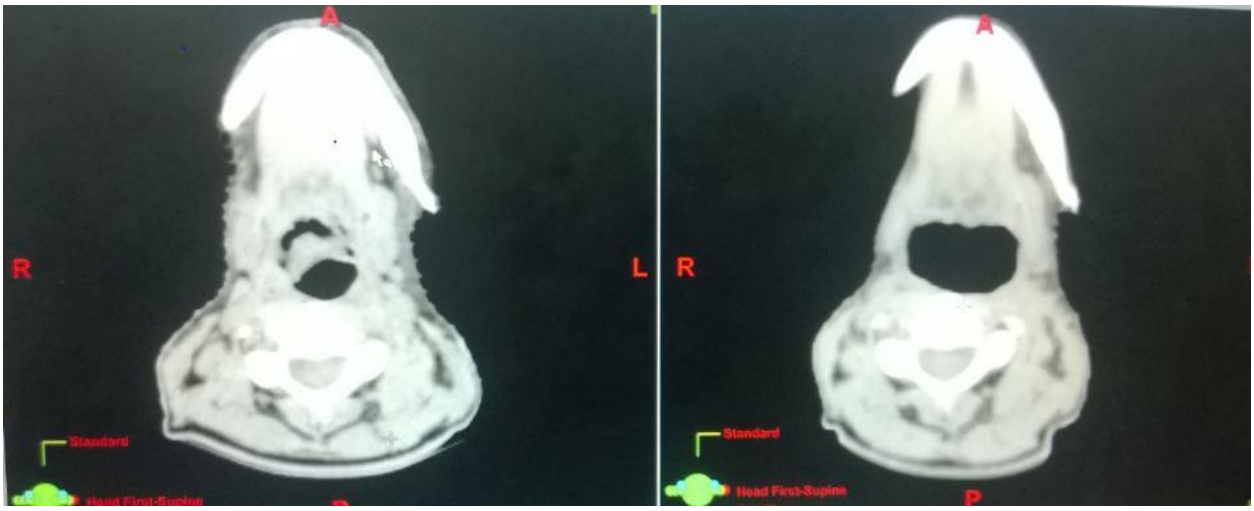
Variable	AP-SE	AP-RE	SI-SE	SI-RE	ML-SE	ML-RE
rC(level A)						
lower	1.3±0.5	1±0.2	2.4±0.9	1.8±0.8	1.6±0.7	1±0.3
higher	0.8±0.5	0.7±0.3	2±1	1.2±0.4	2±0.5	1±0.4
P value	0.018*	0.018*	0.094	0.025*	0.100	0.852
rT(level A)						
Lower	1.2±0.6	0.9±0.3	2.4±1.3	1.6±0.7	2.1±0.6	1.1±0.3
Higher	1±0.4	0.8±0.3	2±0.5	1.2±0.7	1.5±0.6	1±0.3
P value	0.324	0.324	0.460	0.050	0.013	0.216
rBW						
Lower	1.2±0.4	0.9±0.3	2.4±1	1.5±0.5	1.8±0.7	1.1±0.3
Higher	1±0.7	0.9±0.4	2±0.9	1.5±0.9	1.9±0.6	1±0.2
P value	0.376	0.607	0.182	0.323	0.78	0.607

Replanning

Replanning CT done at 40 Gy for all patients.Old plan applied to the replanning CT and difference in NTCP/TCP ratio calculated and correlation between the Body mass factors ,setup errors are analysed .

CT SCAN OF THE PATIENT WITH OROPHARYNGEAL CANCER

SHOWING GOOD REGRESSION:



NTCP AND TCP COMPARISION:

If the patient has large reduction ratio in circumference of (<1) and thickness of (<0.94) at the level of the mastoid tip on the 20th fraction of treatment and larger body weight or height and a performance score of 1-2.Replanning

has showed significant reduction in normal tissue complication probability when compared to patients who had no difference actuall

NTCP	Patients with difference in BMFs and Setup errors	Patients without difference in BMFs and Setup errors
CORD (Mean %)	0.0000001909 %	0.0000026804%
BRAIN STEM(Mean %)	0.0000181882 %	0.0002341159%

III) RESULTS AND ANALYSIS:

DIRECTION	MEAN DISPLACEMENT IN mm	POPULATION SYSTEMATIC ERROR IN mm	CTV-PTV MARGINS SUGGESTED
SUPEROINFERIOR	1.4	2.1	3.3
ANTEROPOSTERIOR	1.5	1	4.6
MEDIOLATERAL	2.1	1.5	6.5

COUCH ROTATION	POPULATION SYSTEMATIC ERROR	POPULATION RANDOM ERROR
DEGREES	0.30	0.34

CORRELATION BETWEEEN COUCH ROTATION AND ERRORS IN OTHER DIRECTIONS

DIRECTION	SYSTEMATIC ERROR	RANDOM ERROR
ANTEROPOSTERIOR	NO CORRELATION	NO CORRELATION
SUPEROINFERIOR	NO CORRELATION	NO CORRELATION
MEDIOLATERAL	P=0.008	P=0.015

#CORRELATION BETWEEN THICKNESS AT LEVEL A AND BODY WEIGHT RATIO-NOT SIGNIFICANT(FROM CBCT AT 20 TH FRACTION)

CORRELATION BETWEEN RATIO OF WEIGHT AND CIRCUMFERENCE AT 10 TH OR 20 TH FRACTION AT ALL THREE LEVELS.

LEVELS	10 TH FRACTION	20 TH FRACTION
LEVEL A	NO CORRELATION	NO CORRELATION
LEVEL B	NO CORRELATION	NO CORRELATION
LEVEL C	NO CORRELATION	NO CORRELATION

CORRELATION BETWEEN PRETREATMENT BMFs AND SETUP ERRORS:

FACTORS	AP-SE	AP-RE	SI-SE	SI-RE	ML-SE	ML-RE	CR-SE	CR-RE
LARGE WEIGHT	P=0.045*	NS	NS	P=0.023*	NS	NS	NS	NS
LONG HEIGHT	NS	NS	NS	P=0.002*	NS	NS	P=0.033*	P=0.067
PS 1 OR 2	P=0.042*	P=0.015*	NS	NS	NS	NS	NS	NS
AGE	NS	NS	NS	NS	NS	NS	NS	NS
BMI	NS	NS	NS	NS	NS	NS	NS	NS

ASSOCIATION BETWEEN BMFs DURING RT(10^{TH} FRACTION)

BMFs	AP-SE	AP-RE	ML-SE	ML-RE	SI-SE	SI-RE
THICKNESS LEVEL A	NS	NS	NS	P=0.043*	NS	NS
THICKNESS LEVEL B	NS	NS	NS	P=0.018*	NS	NS

ASSOCIATION BETWEEN BMFs DURING RT(20TH FRACTION)

BMFs	AP-SE	AP-RE	ML-SE	ML-RE	SI-SE	SI-RE
rC LEVEL A	P=0.018*	P=0.018*	NS	NS	P=0.025*	NS
THICKNESS LEVEL B	NS	NS	P=0.013*	NS	NS	P=0.05*

CORRELATION BETWEEN THICKNESS AT LEVEL A AND COUCH ROTATION(20TH FRACTION)

FRACTION	CR-SE	CR-RE
10TH	NS	NS
20TH	P=O.OO9*	P=O.O19*

***-SIGNIFICANT**

NS-NOT SIGNIFICANT.

#At 10 th fraction thickness at level C and ratio of Circumference at level A,B and C had no effect on setup errors.

#At 20th fraction,ratio of circumference at level B,C had thickness at level B,C had no significant correlation between errors.

IV)DISCUSSION:

Setup uncertainty may change dose distribution to target volume and OARs in head and neck cancers. To overcome this image guided radiotherapy and adaptive radiotherapy are used. According to the ICRU 62, inappropriate CTV-PTV margin leading to setup displacement and organ motion leads to underdose of CTV. To define this margin for Head and neck cancer, variability due to setup uncertainties must be corrected and organ motion may be neglected. But in practical scenario, extensive imaging for daily IGRT is not always feasible.

Based on these results patients with large body weight, height, and PS of 1 or above, can be selected for daily online imaging and adaptive radiotherapy.

CTV to PTV margins should be altered relevantly in all directions if IGRT is not possible. Head and Neck cancer patients receiving RT exhibit significant anatomical changes due to tumor regression after the delivery of therapeutic dose. The geometric change of the target and OARs should be assessed with the help of on-line images acquired during the treatment regimen. Patients having unfit

immobilizations are usually considered for ART. But the correct guidelines for adaptive radiotherapy are still lacking. Albeit the increase in the quality of life of the patients undergoing ART, it also increases the workload of the staff and the cost of the treatment to the patients. This study was done mainly to determine the effect of Body mass factors before and during radiation on positioning displacement for patients treated with Head and neck cancers and to correlate between Body Mass Factors and the extent of daily setup errors. These results helps us to ascertain who should be regarded for on-line image guided radiotherapy before starting RT, and determine those who really require ART to decrease setup error.

V) CONCLUSION:

Head and neck cancer patients with large body weight or height, and performance status score of 1–2 receiving radiation either with or without chemotherapy are recommended to be done daily online imaging. Patients exhibiting a large reduction ratio in circumference (<1) and thickness (<0.94) on the 20^{th} fraction of the treatment at the level of the mastoid tip can be considered for Adaptive planning.

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